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New material of the Early Pleistocene mammalian fauna from Chutoulang, Chifeng, eastern Nei Mongol, China and binary faunal similarity analyses

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Abstract New specimens from a new locality at Chutoulang in eastern Nei Mongol were identified as *Canis chihliensis*, *Coelodonta nihowanensis*, *Hipparion* (*Proboscidipparion*) *sinense*, *Equus sanmeniensis*, *Sus lydekkeri*, *Muntiacus* cf. *M. lacustris*, *Axis shansius*, *Eucladoceros boulei*, *Spirocerus* cf. *S. wongi* and *Bison palaeosinensis*. They enriched the mammalian fauna of Chutoulang to 30 taxa together with the material from Dongliang, Dongcun Beigou and Dongcun Nangou localities. The mammalian fossils from these four localities are all from the same horizon and can be regarded as the same fauna, i.e. Chutoulang fauna. The composition of Chutoulang fauna is the closest to that of Nihewan (*s.s.*) by binary faunal similarity coefficients. The age of Chutoulang fauna is between those of Nihewan (*s.s.*) and Juyuandong at Liucheng according to Brainerd-Robinson's sequence, extinction rates and antiquity coefficients. The numerical age of Chutoulang fauna is estimated between 1.4–1.6 Ma based on those of compared faunas. Carnivora are the most numerous in Chutoulang fauna with 11 taxa, but mostly the small sized ones. Perissodactyla and Artiodactyla make about half of the fauna. They are mostly large sized forms. The presence of numerous browsers or forest dwellers implies the existence of forest or woodland in Chutoulang area during that period. The presence of grazers and openland dwellers indicates the existence of larger area of grassland or steppes than that of woodland or forests. Most members of Chutoulang fauna are temperate habitat dwellers with a few cold-prone forms such as *Ochotona* and *Coelodonta*. The climate in Chutoulang area in the Early Pleistocene was thus similar to that of today. Chutoulang fauna is the most northeastern Early Pleistocene fauna in China and it can be recommended as a type site of the Early Pleistocene mammalian fauna in northeastern China.

Keywords Chutoulang, Chifeng, Nei Mongol; Early Pleistocene; mammalian fauna; binary similarity coefficient

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1 Introduction

Chutoulang is a small town (42°18′28.68″–42°19′16.78″N, 118°37′20.31″–118°38′23.87″E) about 22.5 km west (heading: 287°) of Chifeng City and 329.6 km northeast (headings: 34.35°) of Beijing City. It is administratively belong to Chifeng Municipality of Nei Mongol Autonomous Region and was belong to former Jehol Province (1928–1955) and Liaoning Province (1969–1979). During a field investigation in 1986 around Dongliang village of Chutoulang, Zhang and his students found a fossil assemblage from fluvial-lacustrine deposits (Zhang, 1989). A follow-up excavation yielded about 18 taxa of mammalian fossils: *Ochotona* sp., *Marmota* sp., *Microtus* sp., *Vulpes* sp., *Meles leucurus*, *Meles* sp., *Panthera* sp., *Poguma* sp., *Hipparion* sp., *Proboscidipparion sinense*, *Equus sanmeniensis*, *Coelodonta antiquitatis*, *Axis rugosus*, *Cervus* (*Sika*) *grayi*, Cervinae gen. et sp. indet., *Procapreolus* sp., *Gazelle sinensis*, *Bison palaeosinensis*. The fossil assemblage was regarded as with the same age as that of Xihoudu Paleolithic site and that of Xicun fauna in Shanxi Province. And the deposits bearing the fossils were named as Dongliang Formation (Zhang, 1989).

The follow-up excavations from 1986 to 1987 extended from Dongliang to Beigou and Nangou around Dongcun (Dong Village) of Chutoulang, and the mammalian fossils collected from these two localities include 21 taxa: *Procynocephalus wimani*, *Canis variabilis*, *C. chihliensis* var. *palmidens*, *Nyctereutes sinensis*, *Ursus* sp., *Hyaena licenti*, *Panthera tigris*, *Acinonyx* sp., *Hipparion* sp., *H.* (*Proboscidipparion*) *sinensis*, *Equus sanmeniensis*, *Nestoritherium* sp., *Rhinoceros* cf. *R. sinensis*, *Coelodonta antiquitatis*, *Sus lydekkeri*, *Gazella sinensis*, *Gazella* cf. *G. subgutturosa*, *Cervus* sp., *Bison palaeosinensis*, *Bos* sp., *Paracamelus gigas* (You and Zhang, 1989).

The presence of the “dragon bone”, i.e. mammalian fossils, at Chutoulang not only interested paleontologists, but also illegal fossil hunters. The illegal diggings occurred more and more frequently in recent years and the local government carried out a protection project under the supervision of the Department of Land Resources of Nei Mongol Autonomous Region in order to collect the fossils before the illegal fossil dealers to trade them in black markets. An authorized paleontological excavation was conducted in 2012 at Xiaonanshan fossil locality of Chutoulang, and many new specimens of mammalian fossils were collected which form the material of the present study. The new specimens numbered with prefix of CTL (**C**hu**t**ou**l**ang) are housed in the Division of Land Resources of Songshan District, Chifeng City, Nei Mongol.

Xiaonanshan fossil locality (see online supplementary Google Earth location or visit web address on Baidu Maps at < http://j.map.baidu.com/W8FDB >) is located 2.13 km northeast (heading: 54.13) of Chutoulang and ranges from 42°19′43.30″N to 42°19′46.66″N and from 118°39′07.01″E to 118°39′16.06″E with an average altitude of 688 m. The fossils were unearthed from a main layer of reddish and brownish clay or sandy clay with a thickness of 5–7 m and with a sandwiched layer of grayish silt, especially in or near the sandwiched layer of silt. The main layer corresponds to the lower part of Dongliang Formation yielding mammalian fossils (Zhang, 1989; You and Zhang, 1989).

According to Zhang (1989), Dongliang fossil locality is likely around today's Shahudong Village and about 1 km south of Xiaonanshan locality. Beigou locality of You and Zhang (1989) is north of today's Dahedong Village and probably about 1 km north of Xiaonanshan locality according to the local habitants participated the excavations by Zhang (1989). And Nangou locality of You and Zhang (1989) is very near today's Xiaonanshan locality. All fossils were collected from lower part of a series of fluvial-lacustrine deposits named as Dongliang Formation by Zhang (1989).

2 Systematic paleontology

Mammalia Linnaeus, 1758

Carnivora Bowdich, 1821

Caniformia Kretzoi, 1943

Canidae Fischer de Waldheim, 1817

Caninae Fischer de Waldheim, 1817

***Canis* Linnaeus, 1758**

***Canis chihliensis* Zdansky, 1924**

(Fig. 1)

Material A left M1 (CTL23-2, crown length: 12.92 mm, width: 16.09 mm, height: 8.56 mm) and a broken left m1 (CTL46-6, length: >14.9 mm, width: 9.1 mm, height: 14.2 mm).

Remarks Both M1 and broken m1 show no wear facet and therefore are relatively young. The specimens are morphologically similar to those of *Canis chihliensis* from

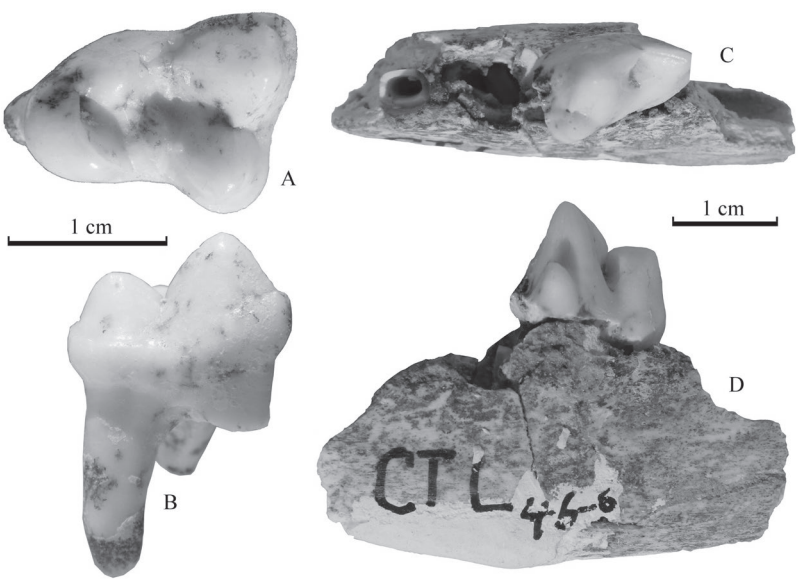

Fig. 1 *Canis chihliensis* from Xiaonanshan Locality
Left M1 (CTL23-2) in occlusal (A) and buccal (B) views;
and left m1 (CTL46-6) in occlusal (C) and lingual (D) views

Xiashagou described by Teilhard de Chardin and Piveteau (1930) and close to those from Shanshenmiaozui (Tong et al., 2012). They are metrically smaller than those of *C. chihliensis* from Xiashagou and Shanshenmiaozui but similar to those of *C. chihliensis* var. *parmidens* and *C. chihliensis* var. *minor* from Xiashagou (Teilhard de Chardin and Piveteau, 1930). The taxonomic status of *C. chihliensis* var. *parmidens* is controversial (Qiu et al. 2004), and *C. chihliensis* var. *minor* was included into the late Neogene form *Eucyon* (Tedford and Qiu, 1996). The present specimens indicate that there existed at Xiaonanshan a kind of relatively small canid similar to *C. chihliensis* with some archaic aspects.

Canis chihliensis is absent at Dongliang locality (Zhang, 1989), but present at Dongcun localities as *C. chihliensis* var. *parmidens* (You and Zhang, 1989). The latter is considered here as *C. chihliensis* together with that from Xiaonanshan.

Perissodactyla Owen, 1848
Rhinocerotoidea Gill, 1872
Rhinocerotidae Gray, 1821
Dicerorhininae Simpson, 1945
***Coelodonta* Bronn, 1831**
***Coelodonta nihowanensis* Kahlke, 1969**

(Fig. 2)

Material A right DP4 (CTL19-1). Length: 49.57 mm, width: 44.90 mm, height: 39.53 mm.

Remarks The crown height of DP4 is moderate and the occlusal view of the crown outline is nearly triangular. The enamel layer is well preserved and the cavity inside of enamel layer is very large. The ectoloph is undulated, anterior fossette is large and connected with wide middle fossette, while the posterior fossette is short and wide.

Chutoulang specimen is close to that of *Rhinoceros* cf. *R. tichorhinus* described by Teilhard de Chardin and Piveteau (1930) which was later defined as *Coelodonta nihowanensis* by Kahlke (1969). It is also close to that of *C. nihowanensis* from Longdan (Qiu et al., 2004) both morphologically and metrically.

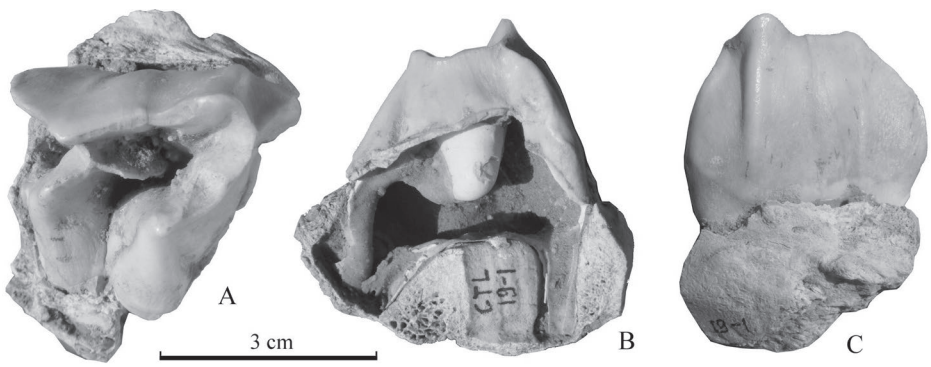

Fig. 2 A righ DP4 (CTL19-1) of *Coelodonta nihowanensis* from Xiaonanshan Locality in occlusal (A), lingual (B) and buccal (C) views

The left M1, right M1, left p4 and right m2 of the "*Coelodonta antiquitatis*" from Dongliang locality described by Zhang (1989) are evidently smaller and more archaic than those of the Late Pleistocene *C. antiquitatis* (Zhang, 1989) and they are actually *C. nihowanensis*. The "*C. antiquitatis*" from Dongcun localities mentioned by You and Zhang (1989) is the same case.

Perissodactyla Owen, 1848

Equidae Gray, 1821

***Hipparion* de Christol, 1832**

***Hipparion* (*Proboscidipparion*) Sefve, 1927**

***Hipparion* (*Proboscidipparion*) *sinense* Sefve, 1927**

(Fig. 3)

Material A left third metacarpal with reduced and broken second and forth metacarpals (CTL33-1), a left third proximal phalange (CTL26).

Fig. 3 *Hipparion* (*Proboscidipparion*) *sinense* from Xiaonanshan Locality
A left third metacarpal with reduced and broken second and forth metacarpals (CTL33-1) in posterior (A), anterior (B) and proximal (C) views; and a left third proximal phalanx (CTL26) in proximal (D), posterior (E) and anterior (F) views

Remarks The left metacarpal III (CTL33-1) is well preserved with just a few minor fractures (Fig. 3A–C). The lateral and medial sides of the distal part of metacarpal III show facets of contact with metacarpals II and IV, an evidence of typical hipparion, although metacarpals II and IV are preserved just two thirds of proximal parts and their distal third parts are broken off (Fig. 3A).

The proximal-distal length of metacarpal III (CTL33-1) measures 267.6 mm, the anterio-posterior diameter and the medial-lateral diameter in the middle of metacarpal III are 32.6 and 35.8 mm respectively. The medial-lateral and anterio-posterior diameters of proximal facet with carpals measure 51.5 and 40.0 mm respectively. And those of distal facet with proximal phalanx III are 44.9 and 36.9 mm respectively. The metacarpals (CTL33-1) are very similar to those of *Hipparion* (*Proboscidipparion*) *sinense* from Yushe Basin (Qiu et al., 1987) and Longdan (Qiu et al., 2004).

The left third proximal phalange (CTL26) is stout, with moderately expanded proximal and distal condyles (Fig. 3D–F). Its length is 79.2 mm, its anterio-posterior diameter is 37.3 mm at the proximal, 30.0 mm in the middle and 24.5 mm at the distal; its medial-lateral diameter is 40.3 mm at the proximal, 43.3 mm at the distal.

Some isolated cheek teeth with isolated protocone in upper cheek teeth from Dongliang locality were included into *Hipparion* (*Proboscidipparion*) *sinense* (Zhang, 1989). The species was also reported present at Dongcun localities (You and Zhang, 1989).

Table 1 Dental measurements of *Equus sanmeniensis* from Xiaonanshan Locality (mm)

	CTL18-1 left				TCL34-2 left	TCL34-2 right	CTL39-1-1 left	CTL39-1-1 right
M3 L	34.54			i1 m-d	15.23	15.31	15.07	
M3 W	28.91			i1 b-l	11.9	10.9	11.93	
M3 Prc L	12.14			i2 m-d	16.06	16.49	13.7	13.49
M3 Prc I	35.15			i2 b-l	11.52	11.89	12.68	12.75
				i3 m-d	15.38	16.87	12.4	12.26
				i3 b-l	10.09	10.9	14.8	15.17
	CTL42-2 left	CTL42-1 right	CTL39-1-1 left	CTL39-1-1 right		CTL42-2 left	CTL42-1 right	CTL30-2 right
p2 L		39	37.54	38.04	m1 L	30.33	29.82	
p2 W		18.78	18.89	18.75	m1 W	21.2	20.9	
p2 d-k		19.83	16.53	16.8	m1 d-k	16.56	15.76	
p2 p-f		14.54	15.71	14.87	m1 p-f	10.05	9.00	
p3 L	35.3	35	35.18	34.98	m2 L	31.06	32.75	40.12
p3 W	21.3	21.03	20.11	19.82	m2 W	19.6	19.82	16.34
p3 d-k	22.05	22.52	21.69	21.86	m2 d-k	16.33	16.27	18.24
p3 p-f	13.92	15.25	11.50	12.59	m2 p-f	11.56	12.09	13.86
p4 L	34.1	34.01	32.75		m3 L	41.2	41.8	39.21
p4 W	22.52	22.84	20.11		m3 W	17.2	17.29	14.14
p4 d-k	20.33	20.86	18.56		m3 d-k	16.43	16.98	13.29
p4 p-f	12.67	12.63	12.09		m3 p-f	11.09	10.24	10.14
p2-4 L		108.1	108		m1-3 L	102.6	105.4	
					p2-m3 L		215.3	

Abbreviations: L. length; W. width; Prc L. length of protocone; Prc I. index of protocone; m-d. mesiodistal diameter; b-l. buccolingual diameter; d-k. length of double knots; p-f. length of postflexid.

Equus Linnaeus, 1758

Equus sanmeniensis Teilhard de Chardin & Piveteau, 1930

(Fig. 4; Table 1)

Material A right mandibular fragment with p2–m3 (CTL42-1), a left mandibular fragment with p3–m3 (CTL42-2), an anterior part of a mandible with all incisors and some cheek teeth (CTL39-1-1), a mandibular symphysis with all incisors (TCL34-2), a right mandibular fragment with m2–3 (CTL30-2), a left M3 (CTL18-1), a left p3 (CTL12-3), a left p4 (CTL14), a right m1 (CTL12-2), a left m2 (CTL12-5), a left m3 (CTL12-1), a left and a right talus (CTL34-1, CTL07-1), a left proximal third phalange (TCL33-5).

Remarks The specimens of the species are the most numerous among the Xiaonanshan material. The protocone of M3 (CTL18-1) is long and nearly triangular in occlusal view and connected to protoconule. The tooth is covered by a cement layer, especially on the lingual side. There are five incomplete lower dentitions. The double-knots pattern of the lower cheek teeth is stenonid.

Xiaonanshan specimens are morphologically close to those of *Equus sanmeniensis*, e.g. the mesostyle of M3 is simple and not folded, its protocone is long; and the pattern of

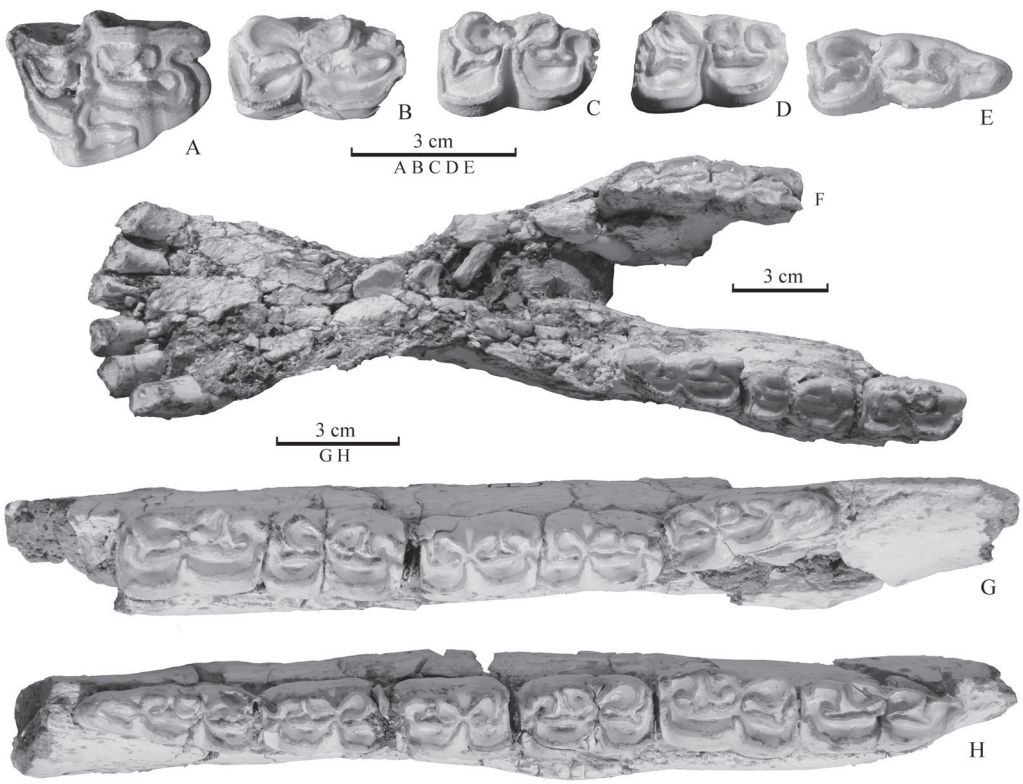

Fig. 4 Occlusal view of *Equus sanmeniensis* from Xiaonanshan Locality

A. a left M3 (CTL18-1); B. a left p3 (CTL12-3); C. a left p4 (CTL14); D. a right m1 (mirror) (CTL12-2); E. a left m3 (CTL12-1); F. the anterior part of a mandible with all incisors and some cheek teeth (CTL39-1-1); G. a left mandibular fragment with p3–m3 (CTL42-2); H. a right mandibular fragment with p2–m3 (CTL42-1)

double-knots in lower cheek teeth is stenonid, ectoflexid extends into the neck of double-knots. The dimensions of Xiaonanshan specimens are relatively large and close to those of *E. sanmeniensis* from Xiashagou of Nihewan (Teilhard de Chardin and Piveteau, 1930), *E. huanghoensis* from Luping (Chow and Liu, 1959) and Tuozidong (Dong and Fang, 2005) and *E. eisenmannae* from Longdan (Qiu et al., 2004), but evidently larger than those of *E. przewalskii* and *E. dalianensis* from Longgushan (Zhou et al., 1985).

E. sanmeniensis was reported present at Dongliang locality (Zhang, 1989), as well as at Dongcun localities (You and Zhang, 1989).

Artiodactyla Owen, 1848

Suoidae Cope, 1887

Suidae Gray, 1821

Suinae Zittel, 1893

***Sus* Linnaeus, 1758**

***Sus lydekkeri* Zdansky, 1928**

(Fig. 5; Table 2)

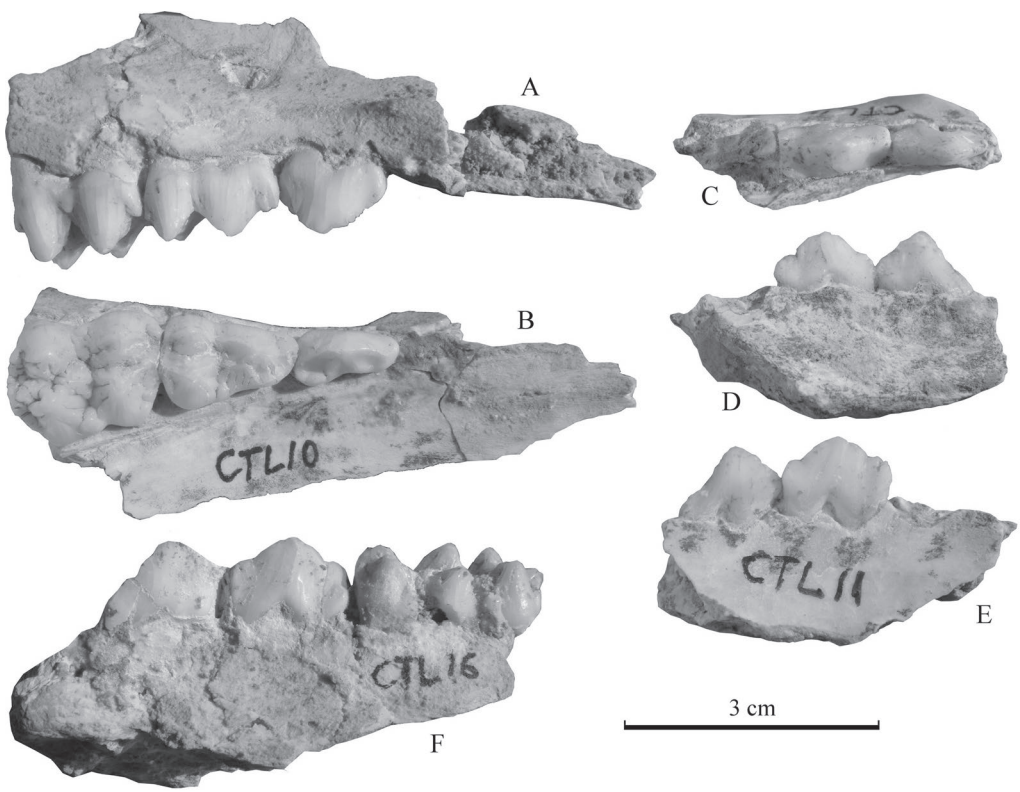

Fig. 5 *Sus lydekkeri* from Xiaonanshan Locality
A right juvenile maxillary fragment with DP2–4 (CTL10) in buccal (A) and occlusal (B) views; a left mandibular fragment with p2–3 (CTL11) in occlusal (C), buccal (D) and lingual (E) views; and a left juvenile mandibular fragment with p2–3 and dp4 (CTL16) in buccal view (F)

Material A right maxillary fragment with DP2–4 (CTL10), a left mandibular fragment with p2–3 (CTL11), a left mandibular fragment with p2–3 and dp4 (CTL16).

Remarks The suid material is fragmental, only juvenile maxillary and mandibular fragments are available. The teeth are typical of suid type. DP4 and dp4 are completely molarized (Fig. 5A–B, F). The p2 and p3 are composed of a main cusp and a few accessory cusplets (Fig. 5C–F). The available morphological and metric as well as stratigraphic data of the material are in accordance with those of *Sus lydekkeri*.

Sus lydekkeri was not reported from Dongliang locality (Zhang, 1989), but present at Dongcun localities (You and Zhang, 1989).

Table 2 Dental measurements of *Sus lydekkeri* from Xiaonanshan Locality (mm)

		Length	Width	Height			Length	Width	Height
CTL10	DP2	12.63	6.62	8.85	CTL16	p2	12.22	4.78	8.91
(right)	DP3	15.51	10.73	7.54	(left)	p3	13.27	5.34	9.46
	DP4	16.24	13.59	8.94		dp4	24.19	10.6	8.58
CTL11	p2	12.69	5.01	9.77					
(left)	p3	12.65	6.17	9.97					

Ruminantia Scopoli, 1777

Pecora Flower, 1883

Cervoidea Simpson, 1931

Cervidae Gray, 1821

Muntiacinae Pocock, 1923 (=Cervulinae Sclater, 1870)

***Muntiacus* Rafinesque, 1815 (=*Cervulus* Blainville, 1816)**

***Muntiacus* cf. *M. lacustris* Teilhard de Chardin & Trassaert, 1937**

(Fig. 6A–B; Table 3)

Material A right maxillary fragment with M2–3 (CTL22-1), a left mandibular fragment with m2–3 (CTL04-2).

Remarks The molars are relatively small (Table 3) and typically selenodont with moderate crown height. The accessory elements such as entostyle (basal pillar), enamel folds on the crests of the main cusps are present in upper molars (Fig. 6A), while precingulid and ectostylid (basal pillar) are present in lower molars (Fig. 6B). The specimens are evidently larger than those of moschids and are morphometrically of muntjacs. Xiaonanshan specimens are metrically within the range of those of *Muntiacus lacustris* from the Early Pleistocene deposits of *Gigantopithecus* Cave of Liucheng (Han, 1987) and Dadong (=Sanhe Cave) of Chongzuo (Dong et al., 2011). Unfortunately the antler material is not available at Xiaonanshan.

The muntjacs were not reported from Dongliang locality (Zhang, 1989) and Dongcun localities (You and Zhang, 1989). But a moderate cervid *Procapreolus* sp. represented by a mandibular fragment with m2–3 was reported from Dongliang (Zhang, 1989). The cervids from Dongcun localities are only a *Cervus* sp. (You and Zhang, 1989). Xiaonanshan specimens are slightly larger than those of *Procapreolus jinensis* from the Late Miocene deposits of Yushe Basin (Dong and Ye, 1996), as well as those of extant *Capreolus capreolus* housed at

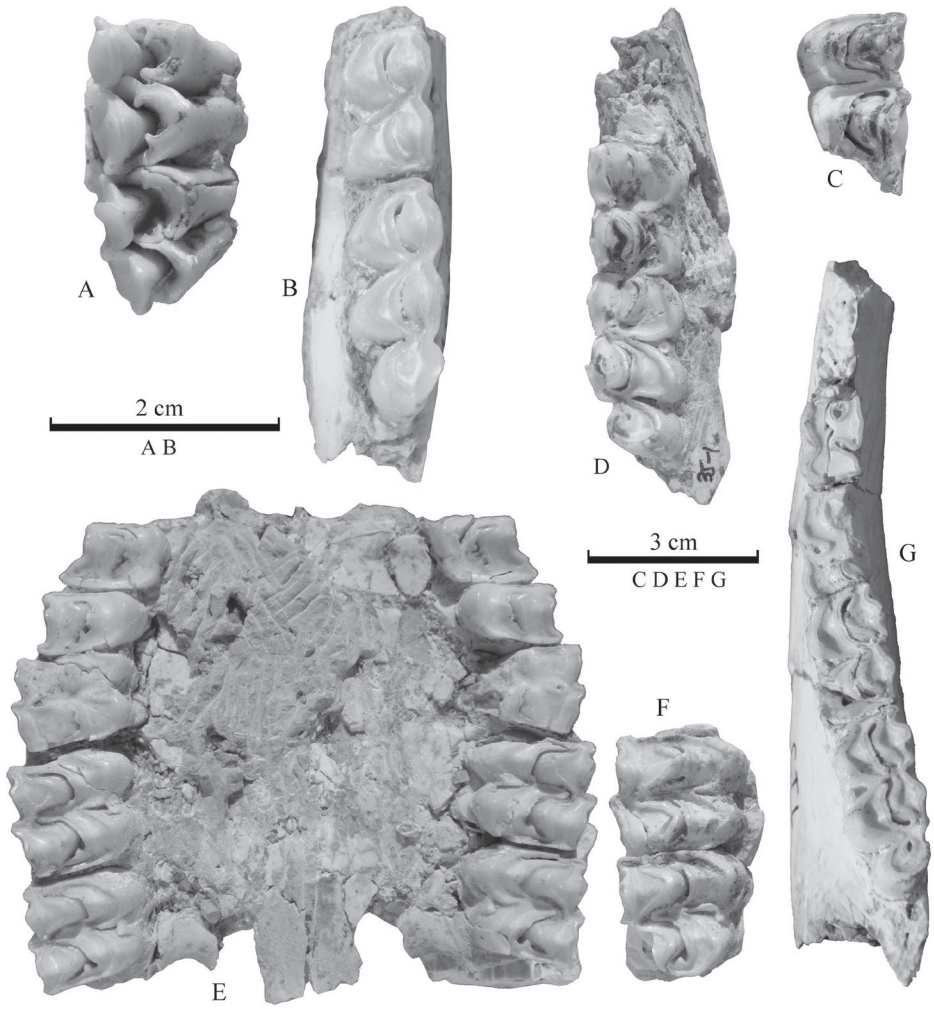

Fig. 6 Cervidae from Xiaonanshan Locality in occlusal view

A–B. *Muntiacus* cf. *M. lacustris*: a right maxillary fragment with M2–3 (CTL22-1) (A) and a left mandibular fragment with m2–3 (CTL04-2) (B); C–D. *Eucladoceros boulei*: a left M3 (CTL08) (C) and a right mandibular fragment with m2–3 (CTL35-1) (D); E–G. *Axis shansius*: a maxillary fragment with both left and right P3–M3 (CTL05-1) (E), a right maxillary fragment with M2–3 (CTL12-10) (F) and a left mandibular fragment with p4–m3 (CTL42-6) (G)

Laboratoire d'Anadomie comparée de Paris (e.g. 1948-46, Sl-1erE-38; 1951-228, Sl-RC-t369). The *Procapreolus* sp. from Dongliang reported by Zhang (1989) is therefore more likely a muntjac as that from Xiaonanshan.

Cervinae Baird, 1857

***Eucladoceros* Falconer, 1868**

***Eucladoceros boulei* Teilhard de Chardin & Piveteau, 1930**

(Fig. 6C–D; Table 3)

Material A left M3 (CTL08), a right mandibular fragment with m2–3 (CTL35-1).

Table 3 Dental measurements of ruminants from Xiaonanshan Locality (mm)

		Length	Width	Height			Length	Width	Height
Muntiacus cf. *M. lacustris*									
CTL22-1	M2	13.24	11.21	12.52	CTL04-2	m2	13.18	8.71	5.66
(right)	M3	12.12	10.11	12.29	(left)	m3	19.5	8.16	9.07
Eucladoceros boulei									
CTL08	M3	29.72	20.37	16.49	CTL35-1	m2	23.68	16.17	5.81
(left)					(right)	m3	33.51	15.82	9.17
Axis shansius									
CTL05-1	P3	15.84	21.31	7.46	CTL05-1	P3	15.83	21.44	8.0
(right)	P4	14.57	19.01	9.51	(left)	P4	14.5	18.93	9.32
	M1	18.25	22.29	8.99		M1	18.38	22.45	8.68
	M2	21.68	23.73	11.27		M2	21.1	23.34	11.5
	M3	21.1	22.58	12.41		M3	21.29	23.11	11.66
CTL12-10	M2	21.34	24.47	10.54	CTL42-6	p4		10.86	9.25
(right)	M3	22.34	22.11	11.25	(left)	m1	18.62	12.67	5.18
						m2	21.15	14.2	10.3
						m3	29.57	13.89	12.13
Spirocerus cf. *S. wongi*					*Bison palaeosinensis*				
CTL18-2	m2	21.8	13.38		CTL27	m1	28.6	15.12	
(left)	m3	28.56	12.65		(right)	m2	33.06	14.66	

Remarks The M3 is composed of four selenodont main cusps and without evident accessory elements such as enamel fold on the crests of the lingual main cusps and cingula. The m2 and m3 are also composed with selenodont main cusps with weak precingulid and ectocingulid as well as developed ectostylid (basal pillar).

The specimens represent a relatively large cervid (see Table 3 for measurements). The only cervid with similar size in the Early Pleistocene is *Eucladoceros boulei* from Nihewan Basin (Teilhard de Chardin and Piveteau, 1930) and Xiaonanshan specimens can also be regarded as the same species although there is no antler material. *Eucladoceros boulei* was not reported from either Dongliang (Zhang, 1989) or Dongcun (You and Zhang, 1989) localities and it is its first discovery in Chutoulang area.

Axis Smith, 1827

Axis shansius Teilhard de Chardin & Trassaert, 1937

(Fig. 6E–G; Table 3)

Material A maxillary fragment with both left and right P3–M3 (CTL05-1), a right maxillary fragment with M2–3 (CTL12-10), a left mandibular fragment with p4–m3 (CTL42-6), a left calcaneus (CTL02-2) and a left talus (CTL07-2).

Remarks The P3 is composed of two fused lobes with an evident entoflexus, and P4 a single lobe without entoflexus. The M1–3 are all composed of four selenodont main cusps with evident spur, entocingulum and entostyle (basal pillar), the other accessory elements are absent. The precingulid and ectostylid (basal pillar) are evident in all lower molars. The first lobe is longer than the second one in m1 and m2, but nearly equal in m3. The third lobe of m3 is relatively small. Xiaonanshan specimens are evidently smaller than those of *Elaphurus*

bifurcatus, *Eucladoceros boulei* and *Cervus* (*Rusa*) *elegans* from Nihewan (Teilhard de Chardin and Piveteau, 1930) but close to those of *Axis shansius* from Yushe Basin (Teilhard de Chardin and Trassaert, 1937) and Dajushan (Dong, 2006).

The body of calcaneus (CTL02-2) is relatively short with a length of 66.52 mm and an anterior-posterior diameter of 40.89 mm, the anterio-posterior diameter of calcaneal tuber measures 34.8 mm, the sustentaculum tali and coracoid process are developed. The proximal trochlea is more developed than that of the distal in the talus (CTL07-2), and the transversal and anterio-posterior diameters of the proximal trochlea are 46.89 and 35.67 mm respectively, and those of the distal are 44.28 and 34.05 mm respectively.

The reported fragmental material of "*Cervus* (*Sika*) *grayi*" from Dongliang (Zhang, 1989) can also be regarded as *Axis shansius* because *Cervus* (*Sika*) *grayi* is mostly present in the Middle Pleistocene and Dongliang specimens are also morphologically close to those of *Axis shansius* from Yushe.

Bovidae Gray, 1821

Antilopinae Baird, 1857

***Spirocerus* Boule & Teilhard de Chardin, 1928**

***Spirocerus* cf. *S. wongi* Teilhard de Chardin & Piveteau, 1930**

(Fig. 7A–B; Table 3)

Material A left mandibular fragment wit m2–m3 (CTL18-2).

Remarks The m2–3 are high crowned without accessory elements such as cingula and ectostylid (basal pillar), the lingual main cusps are higher than those of the buccal side, the crests of the main cusps are sharp. All these characters indicate an antelope. The specimens are morphologically close to those of *Spirocerus wongi* from Nihewan (Teilhard de Chardin and Piveteau, 1930), but the dimensions are slightly smaller.

Gazella sinensis was reported from Dongliang locality (Zhang, 1989). It was also reported from Dongcun localities together with *Gazella* cf. *G. subgutturosa* (You and Zhang, 1989). Both of the gazelles are evidently smaller than *Spirocerus wongi*.

Bovinae Gray, 1821

***Bison* Smith, 1827**

***Bison palaeosinensis* Teilhard de Chardin & Piveteau, 1930**

(Fig. 7C–D; Table 3)

Material A right mandibular fragment with m1–2 (CTL27).

Remarks The material is very limited at Xiaonanshan Locality, but the specimen CTL27 is clearly of a bovine, e.g. the crowns are very high, the ectostylids (basal pillar) and the enamel folds of the main cusp crests are developed. A primitive bovine, *Bison palaeosinensis* was reported from Dongliang locality (Zhang, 1989). It is represented by a complete horn core with partial frontal, four isolated upper molars and a pair of mandibles with cheek dentitions.

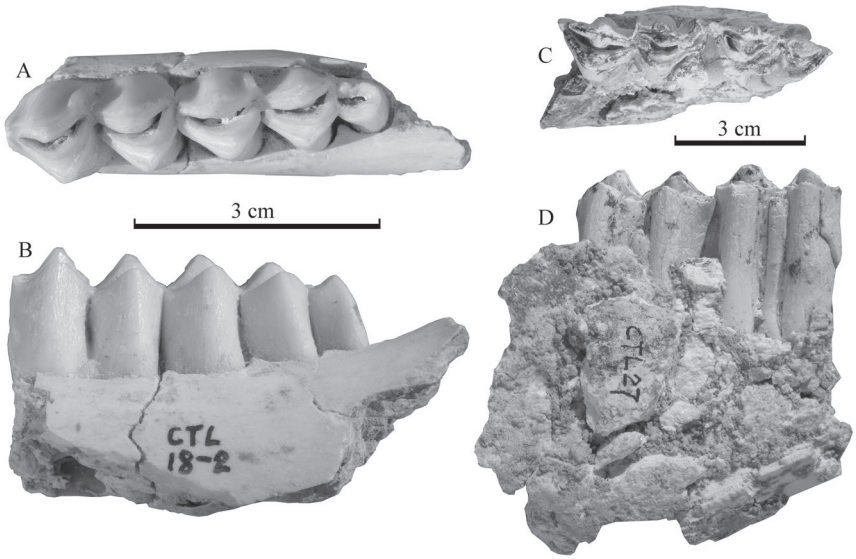

Fig. 7 Bovidae from Xiaonanshan Locality
A–B. *Spirocerus* cf. *S. wongi*: occlusal (A) and buccal (B) views of a left mandibular fragment with m2–3 (CTL18-2); C–D. *Bison palaeosinensis*: occlusal (C) and buccal (D) views of a right mandibular fragment with m1–2 (CTL27)

It was also reported from Dongcun localities (You and Zhang, 1989). Xiaonanshan specimen is therefore very likely of *Bison palaeosinensis* although the frontal appendages are absent.

3 Fauna analyses

All specimens collected from 2012's excavation can be thus identified into 10 taxa as mentioned above, and among which *Muntiacus* cf. *M. lacustris*, *Eucladoceros boulei* and *Spirocerus* cf. *S. wongi* are newly identified taxa in Chutoulang area. Together with those from Dongliang locality (Zhang, 1989) and Dongcun localities (You and Zhang, 1989), the identified mammalian taxa from Chutoulang area total 30: *Procynocephalus wimani*; *Ochotona* sp.; *Marmota* sp.; *Microtus* sp.; *Vulpes* sp.; *Canis variabilis*; *Canis chihliensis*; *Nyctereutes sinensis*; *Meles meles* (=*leucurus*); *Meles* sp.; *Poguma* sp.; *Ursus* sp.; *Pachycrocuta brevirostris licenti* (=*Hyaena licenti*); *Panthera tigris*; *Acinonyx* sp.; *Rhinoceros* cf. *R. sinensis*; *Coelodonta nihowanensis*; *Hipparion* (*Proboscidipparion*) *sinensis*; *Equus sanmeniensis*; *Nestoritherium* sp.; *Sus lydekkeri*; *Paracamelus gigas*; *Muntiacus* cf. *M. lacustris*; *Axis shansius*; *A. rugosus*; *Eucladoceros boulei*; *Spirocerus* cf. *S. wongi*; *Gazella sinensis*; *G.* cf. *G. subgutturosa*; *Bison palaeosinensis*. They were unearthed from the same horizon, i.e. a layer of reddish and brownish clay or sandy clay with a sandwiched layer of grayish silt, the fossil localities are close to each other, and all taxa can therefore be regarded as the same fauna, i.e. Chutoulang fauna.

Material and methods In order to find the compositional, zoogeographic and biochronological positions of Chutoulang fauna, some representative Early Pleistocene faunas

from different areas of China and with the taxon number above 30 such as Nihewan (*s.s.*) (Teilhard de Chardin and Piveteau, 1930; Qiu, 2000; Tong et al., 2011) in northern China, Gongwangling (Hu and Qi, 1978) and Longdan (Qiu et al., 2004) in northwestern China, Renzidong (Jin and Liu, 2009) in eastern China, Longgupo (Huang and Fang, 1991) and Longgudong (Zheng, 2004) in central China, Juyuandong (Pei, 1987; Han, 1987) and Dadong (Jin et al., 2009) in southern China, were selected for comparison. A French fauna from upper Saint-Vallier (LD3) (Guérin et al., 2004) was also selected as a classic European Villafranchian fauna for comparison.

Because the presence or absence of a taxon in a fauna is a binary variable, the matching coefficients between binary variables can be used to evaluate the similarity of two faunas (Chen, 1983, 2005). If taxon k is either present or absent both in fauna i and fauna j, we define the matching coefficient of taxon k (R_{ijk}) in the paired faunas as $R_{ijk} = 1$; if taxon k is only present either in fauna i or fauna j, we define the matching coefficient of taxon k (R_{ijk}) in the faunas as $R_{ijk} = 0$. In the case some taxon can only be identified at genus or family level, the matching coefficient is defined as $R_{ijk} = 0.5$. The binary faunal similarity coefficient of two compared faunas (R_{ij}) is defined as the double sum of the matching coefficients of all taxa of the paired faunas:

$$R_{ij} = 2 \times \sum_{k=1}^{n} R_{ijk}$$

All extinct taxa, including regional extinct ones, from all compared faunas were considered as a presumed archaic fauna and those of extant taxa as a presumed modern fauna. All compared faunas as well as the presumed archaic and modern faunas were compared with each other in pairs to find all binary faunal similarity coefficients. The latter were then sequenced by antiquity coefficients which was defined as the binary faunal similarity coefficient between a fauna and the presumed archaic fauna (Dong et al., 2013; Dong, 2016), and they were also ranked according to Brainerd-Robinson's (B.-R.) rule (Chen, 2005) in ascending order from the youngest to the oldest (Table 4). The fauna extinction rate is as classically defined as the percentage of extinct taxa number over total taxa number of the fauna. It is often the case that each fauna being sorted in different position in different sequence by corresponding criterion. In order to get a comprehensive result, we define a B.-R. index for each fauna in B.-R. sequence as its sequence position number (Table 5). We define an extinction index of a fauna k as E_{xk}, the maximal extinction rate of the compared faunas as E_{max}, the minimal extinction rate as E_{min}, the number of compared faunas as n, the extinction rate of the fauna k as E_k, the extinction index E_{xk} of the fauna k can then be calculated by the following formula:

$$E_{xk} = (E_k - E_{min}) \div [(E_{max} - E_{min}) \div (n - 1)] + 1$$

The antiquity index of a fauna is defined and calculated in the same way by replacing the extinction rates with the antiquity coefficients of the faunas (Table 5). We sum up then three

Table 4 Binary faunal similarity coefficients of compared faunas – sequenced according to Brainerd-Robinson's rule

	Md	GWL	LGD	DD	JYD	**CTL**	LD	NHW	StV	LGP	RZD	Arc
Md	624											
GWL	426	624										
LGD	392	440	624									
DD	422	504	488	624								
JYD	416	512	470	560	624							
CTL	**415**	**521**	**447**	**527**	**521**	**624**						
LD	390	504	440	512	508	**527**	624					
NHW	382	486	412	478	482	**541**	508	624				
StV	386	478	418	486	484	**497**	492	458	624			
LGP	366	410	434	460	458	**437**	414	388	386	624		
RZD	358	408	398	438	424	**443**	424	404	398	378	624	
Arc	0	198	232	202	208	**209**	234	242	238	258	266	624

Abbreviations of the faunas: Arc. presumed archaic fauna; CTL. Chutoulang fauna; DD. Dadong fauna; GWL. Gongwangling fauna; JYD. Juyuandong (*Gigantopithecus* Cave) fauna; LD. Longdan fauna; LGD. Longgudong fauna; LGP. Longgupo fauna; Md. presumed modern fauna; NHW. Nihewan (*s.s.*) fauna; RZD. Renzidong fauna; StV. Saint-Vallier fauna.

indices of a fauna in each sequence as its combined index, and sort the faunas in ascending order according to their combined indices.

Results All binary faunal similarity coefficients of compared faunas mentioned above are listed in Table 4. In terms of binary faunal similarity coefficients (Table 4), the most similar fauna to that of Chutoulang is that of Nihewan (*s.s.*) (541), followed by those of Longdan and Dadong (527), Juyuandong and Gongwangling (521), that of Saint-Vallier (497), Longgudong (447), Renzidong (443), and lastly Longgupo (437). But in terms of sequenced binary similarity coefficients according to Brainerd-Robinson's rule (Table 4), the most similar faunas to that of Chutoulang are those of Longdan and Juyuandong, followed by those of Nihewan (*s.s.*) and Dadong, Saint-Vallier and Longgudong, Gongwangling and Longgupo, and lastly that of Renzidong.

As listed in Table 5, Chutoulang fauna is the fifth youngest one among all compared

Table 5 Biochronological sequences according to different criteria

Fauna	B.-R. index	Fauna	Antiquity coefficient	Antiquity index	Fauna	Extinction rate	Extinction index	Fauna	Combined index
GWL	1	GWL	198	1.00	DD	61.1	1.00	GWL	3.58
LGD	2	DD	202	1.53	GWL	63.4	1.58	DD	5.53
DD	3	JYD	208	2.32	LGD	65.9	2.21	LGD	9.71
JYD	4	**CTL**	**209**	**2.46**	LGP	69.6	3.14	JYD	9.92
CTL	**5**	LGD	262	5.50	JYD	71.4	3.60	**CTL**	**12.39**
LD	6	LD	264	5.76	RZD	72.5	3.87	NHW	20.59
NHW	7	StV	268	6.29	**CTL**	**76.7**	**4.93**	LGP	21.08
StV	8	NHW	242	6.82	NHW	85.4	7.13	StV	21.50
LGP	9	LGP	258	8.94	StV	85.7	1.20	LD	21.76
RZD	10	RZD	266	10.00	LD	96.8	10.00	RZD	23.87

Note: abbreviations of the faunas are as in Table 4.

faunas according to Brainerd-Robinson's rule. It is the fourth youngest fauna among all compared faunas after those of Gongwangling, Dadong and Juyuandong according to faunal antiquity coefficients. It is the fourth oldest one among all compared faunas after those of Longdan, Saint-Vallier and Nihewan (*s.s.*) according to extinction rates. It is also the fifth youngest one among all compared faunas after those of Gongwangling, Dadong, Longgudong and Juyuandong according to comprehensive criteria.

4 Discussion and conclusion

Based on binary faunal similarity coefficients (Table 4), the relationship between Chutoulang fauna and that of Nihewan (*s.s.*) is the closest. It is in accordance with their zoogeographic context. But in terms of sequenced binary similarity coefficients according to B.-R.'s rule (Table 4), the most similar faunas to that of Chutoulang are those of Longdan and Juyuandong. The close relationship between Chutoulang and Longdan is also found in binary faunal similarity coefficients and these faunas are both in Palaeoarctic region. But with Juyuandong of Oriental region, it can be interpreted only by their biochronological context (Table 5). Although Saint-Vallier fauna is geographically the farthest among all compared ones, it is not the least similar fauna to that of Chutoulang both in view of binary faunal similarity coefficients and according to B.-R.'s sequence. It might indicate that Chutoulang fauna and that of Saint-Vallier were in the same zoogeographic region (Palaeoarctic) as well as similar biochronological period.

The age of Chutoulang fauna was regarded equivalent to that of Nihewan (*s.s.*) (Zhang, 1989; You and Zhang, 1989). Chutoulang fauna is biochronologcially the closest to that of Longdan and Juyuandong according to B.-R.'s sequence, the closest to that of Longgudong and Juyuandong in terms of antiquity coefficients, the closest to that of Renzidong and Nihewan (*s.s.*) in view of extinction rates and between those of Nihewan and Juyuandong with regards to combined evaluating criteria (Table 5).

The combined correlations also indicate that the faunas of Nihewan (*s.s.*), Longgupo, Saint-Vallier and Longdan are biochronologically very close to each other, the differences between their combined indices are very small. Indeed, Nihewan (*s.s.*) fauna resides in the Matuyama reverse chron between the pre-Reunion Matuyama and the post-Olduvai Matuyama chrons with an estimated age of ca. 2.2–1.7 Ma (Liu et al., 2012); the age of Longgupo fauna from the middle zone of the cave deposits was estimated from 1.12 Ma by ESR to 1.96 Ma by paleomagnetism (Huang et al., 1995); the Saint-Vallier fauna which is one of the standard middle Villafranchian faunas equivalent to biozone MNQ17 was correlated to Chron C2r between 1.95 and 2.58 Ma (Sen, 2004) and generally accepted as about 2 Ma (Guérin et al., 2004); Longdan fauna was dated with paleomagnetism as 2.55–2.16 Ma and generally regarded as 2.2 Ma (Qiu et al., 2004). Juyuandong fauna has not yet been dated by paleomagnetic, ESR nor other physic or chemical methods. Longgudong fauna was dated paleomagnetically as

2.42–2.15 Ma (Zheng, 2004) but it was questioned and Longgudong fauna was considered as younger than that of Longgupo (Jin et al., 2009). Dadong fauna was dated also by paleomagnetism as 1.2 Ma (Jin et al., 2009). The numerical age of Chutoulang fauna should therefore be younger than 1.8 Ma and older than 1.2 Ma, and likely about 1.4–1.6 Ma.

The identified new material from Xiaonanshan locality of Chutoulang totals ten taxa: *Canis chihliensis*, *Coelodonta nihowanensis*, *Hipparion* (*Proboscidipparion*) *sinense*, *Equus sanmeniensis*, *Sus lydekkeri*, *Muntiacus* cf. *M. lacustris*, *Axis shansius*, *Eucladoceros boulei*, *Spirocerus* cf. *S. wongi* and *Bison palaeosinensis*.

Xiaonanshan is the fourth fossil locality of Chutoulang besides previously uncovered Dongliang, Dongcun Beigou and Dongcun Nangou localities. The mammalian fossils from these four localities are all from the same horizon and can be regarded as the same fauna, i.e. Chutoulang fauna.

Carnivora are the most numerous in Chutoulang fauna with 11 taxa, but mostly the small sized ones. The taxa of Perissodactyla and Artiodactyla make about half of the fauna. They are mostly large sized animals. The presence of numerous browsers or forest dwellers such as *Procynocephalus wimani*, *Poguma* sp., *Ursus* sp., *Panthera tigris*, *Rhinoceros* cf. *R. sinensis*, *Nestoritherium* sp., *Sus lydekkeri*, *Muntiacus* cf. *M. lacustris*, *Axis shansius*, *A. rugosus*, *Eucladoceros boulei* implies the existence of forest or woodland in Chutoulang area. The presence of grazers and openland dwellers such as *Ochotona* sp., *Marmota* sp., *Microtus* sp., *Vulpes* sp., *Canis variabilis*, *C. chihliensis*, *Nyctereutes sinensis*, *Pachycrocuta brevirostris licenti* (=*Hyaena licenti*), *Acinonyx* sp., *Coelodonta nihowanensis*, *Hipparion* (*Proboscidipparion*) *sinensis*, *Equus sanmeniensis*, *Spirocerus* cf. *S. wongi*, *Gazella sinensis*, *G.* cf. *G. subgutturosa*, *Bison palaeosinensis* indicates larger area of grassland or steppes than that of woodland or forests. The most members of Chutoulang fauna are temperate habitat dwellers with a few cold prone forms such as *Ochotona* and *Coelodonta*. The climate in Chutoulang area in the Early Pleistocene was thus similar to that of today.

Chutoulang fauna is the most northeastern Early Pleistocene mammalian fauna in China and it can be recommended as a type site of the Early Pleistocene mammalian fauna in northeastern China.

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内蒙古赤峰初头朗早更新世哺乳动物群的新材料及二元相似性分析

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摘要：出土于内蒙古赤峰初头朗小南山地点的哺乳动物化石新材料有直隶犬(*Canis chihliensis*)，泥河湾披毛犀(*Coelodonta nihowanensis*)，中国长鼻三趾马(*Hipparion* (*Proboscidipparion*) *sinense*)，三门马(*Equus sanmeniensis*)，李氏野猪(*Sus lydekkeri*)，湖鹿相似种(*Muntiacus* cf. *M. lacustris*)，山西轴鹿(*Axis shansius*)，布氏真枝角鹿(*Eucladoceros boulei*)，翁氏转角羚羊(*Spirocerus* cf. *S. wongi*)及古中华野牛(*Bison palaeosinensis*)。加上此前在初头朗东梁、东村北沟和东村南沟3个地点出土的标本，初头朗一带出土的哺乳动物化石种类增加到30个。初头朗4个地点的哺乳动物化石产自同一层位，属于同一个动物群。根据动物群的二元相似性系数，初头朗动物群在组成上最接近狭义泥河湾动物群。综合Brainerd-Robinson排序结果、动物群古老系数和动物群中绝灭种类的百分比，初头朗动物群的时代介于狭义泥河湾动物群和柳城巨猿洞动物群之间；而根据与相关动物群年龄值的对比，初头朗动物群的年龄值约在1.4–1.6 Ma之间。初头朗动物群中的食肉目种类有11个，但大多为小型种类。奇蹄目和偶蹄目种类的总和占动物群总数的一半，大多为体型较大的种类。该动物群中的嫩食者和林栖者指示当时存在一定范围的森林和林地；而动物群中的粗食者及开阔地栖息者指示当时存在面积较大的草原和草甸。初头朗动物群的大部分种类是喜温动物，喜冷种类只有鼠兔和披毛犀，因此当时的气候与现今大致相同。在地理位置上初头朗动物群是我国最靠北和最靠东的早更新世动物群，因此可以推荐为东北地区的早更新世哺乳动物群典型地点。

关键词：内蒙古赤峰初头朗，早更新世，哺乳动物群，二元相似性系数

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References

Chen T M, 1983. Chronological sequence of six Late Pleistocene faunas in North China with Brainerd-Robinson method. Acta Anthtop Sin, 2(2): 196–202

Chen T M, 2005. Quantitative Archaeology. Beijing: Peking University Press. 1−231

Chow M C, Liu H Y, 1959. New materials of the Pleistocene equid from Shanxi. Vert PalAsiat, 1(3): 133−136

Dong W, 2006. Early Pleistocene ruminants (mammals) from the Dajushan, Huainan, Anhui Province (China). Vert PalAsiat, 44(4): 332−346

Dong W, 2016. Biochronological framework of *Homo erectus* horizons in China. Quatern Int, 400: 47–57

Dong W, Fang Y S, 2005. Fossil equids (mammals) from the Tuozidong, Nanjing (China) and its significance. Vert PalAsiat, 43(1): 36−48

Dong W, Ye J, 1996. Two new cervid species from the late Neogene of Yushe Basin, Shanxi Province, China. Vert PalAsiat,

34(2): 135–144

Dong W, Pan W S, Sun C K et al., 2011. Early Pleistocene ruminants from Sanhe Cave, Chongzuo, Guangxi, South China. Acta Anthrop Sin, 30(2): 192−205

Dong W, Liu J Y, Fang Y S, 2013. The large mammals from Tuozidong (eastern China) and the Early Pleistocene environmental availability for early human settlements. Quatern Int, 295: 73–82

Guérin C, Faure M, Argant A et al., 2004. Le gisement pliocène supérieur de Saint-Vallier (Drôme, France): synthèse biostratigraphique et paléoécologique. Geobios, 37: S349–S360

Han D F, 1987. Artiodactyla fossils from Liucheng *Gigantopithecus* Cave in Guangxi. Mem Inst Vert Paleont Paleoanthrop, Acad Sin, 18: 135–208

Hu C K, Qi T, 1978. Gongwangling Pleistocene mammalian fauna of Lantian, Shaanxi. Palaeont Sin, New Ser C, 21: 1−64

Huang W B, Fang Q R, 1991. Wushan Hominid Site. Beijing: China Ocean Press. 1–230

Huang W P, Ciochon R, Gu Y M et al., 1995. Early *Homo* and associated artifacts from Asia. Nature, 378: 275–278

Jin C Z, Liu J Y, 2009. Paleolithic Site – The Renzidong Cave, Fanchang, Anhui Province. Beijing: Science Press. 1–439

Jin C Z, Qin D G, Pan W S et al., 2009. A newly discovered *Gigantopithecus* fauna from Sanhe Cave, Chongzuo, Guangxi, South China. Chinese Sci Bull, 54(5): 788–797

Kahlke H-D, 1969. Die Rhinocerotiden-Reste aus den Kiesen von Süßenborn bei Weimar. Paläont Abh A, 3(3/4): 667–709

Liu P, Deng C, Li S et al., 2012. Magnetostratigraphic dating of the Xiashagou Fauna and implication for sequencing the mammalian faunas in the Nihewan Basin, North China. Palaeogeogr, Palaeoclimatol, Palaeoecol, 315-316: 75–86

Pei W Z, 1987. Carnivora, Proboscidea and Rodentia from Liucheng *Gigantopithecus* Cave and other caves in Guangxi. Mem Inst Vert Paleont Paleoanthrop, Acad Sin, 18: 5–118

Qiu Z X, 2000. Nihewan fauna and Q/N boundary in China. Quaternary Sci, 20(2): 142–154

Qiu Z X, Huang W L, Guo Z H, 1987. The Chinese hipparionine fossils. Palaeont Sin, New Ser C, 25: 1−250

Qiu Z X, Deng T, Wang B Y, 2004. Early Pleistocene mammalian fauna from Longdan, Dongxiang, Gansu, China. Palaeont Sin, New Ser C, 27: 1−198

Sen S, 2004. Magnetostratigraphy of the Villafranchian mammal locality of Saint-Vallier (Drôme). Geobios, 37: S58–S61

Teilhard de Chardin P, Piveteau J, 1930. Les mammifères fossils de Nihowan (Chine). Ann Paléont, 19: 1–134

Teilhard de Chardin P, Trassaert M, 1937. Pliocene Camelidae, Giraffidae and Cervidae of S. E. Shansi. Palaeont Sin, New Ser C, 1: 1–56

Tedford R H, Qiu Z X, 1996. A new canid genus from the Pliocene of Yushe, Shanxi Province. Vert PalAsiat, 34(1): 27–48

Tong H W, Tang Y J, Yuan B Y, 2011. Biostratigraphy division of vertebrate fossils. In: Yuan B Y, Xia Z K, Niu P S eds. Nihewan Rift and Ancient Human. Beijing: Geological Publishing House. 47–60

Tong H W, Hu N, Wang X M, 2012. New remains of *Canis chihliensis* (Mammalia, Carnivora) from Shanshenmiaozui, a Lower Pleistocene site in Yangyuan, Hebei. Vert PalAsiat, 50(4): 335−360

You Y Z, Zhang W S, 1989. An Early Pleistocene mammalian fauna at Dongcun, Chifeng district, Nei Mongol. Quaternary Sci, 9(1): 48–55

Zhang W S, 1989. The discovery and stratigraphic bearing of the mammalian fauna in Dongliang, Chutoulang, Chifeng City (1). J Heb Colg Geol, 12(1): 69–80

Zheng S H, 2004. Jianshi Hominid Site. Beijing: Science Press. 1–412

Zhou X X, Sun Y F, Xu Q Q et al., 1985. Note on a new Late Pleistocene *Equus* from Dalian. Vert PalAsiat, 23(1): 69−76